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NAVIGATION BY THE STARS

By FRANK S. HOGG

(THE ADDRESS OF THE PRESIDENT OF THE ROYAL ASTRONOMICAL SOCIETY OF CANADA)

Historical Introduction

NAVIGATION, according to the Oxford Dictionary, is the art or science of directing the movements of vessels on the sea, including, more especially, the methods of determining the ship's position and course by principles of geometry and nautical astronomy. In more flowery seventeenth century language, navigation is "that science which has been particularly valued by the ancients, especially by our Ancestors of this Island; for it is the beauty and bulwark of England, the wall and wealth of Britain, and the bridge that links her with the Universe."

In very early times navigation was limited to coasting operations by small craft which did not lose the shelter of the shores, travelled only a few leagues a day, and usually put in to shore for the night or during adverse weather. Later larger vessels were capable of withstanding the open seas, and of providing living quarters for the crew and passengers. This permitted voyages out of sight of land bearings, and demanded a new method of navigation. Very early this was supplied by astronomical means.

It was recognized that directions could be determined by reference to the stars. Thus the Phoenicians, in ships of Lebanon cedar, developed sea navigation of the Mediterranean, using the constellation Ursa Minor. Aratos, in his description of the constellations, contrasts the Great Bear and the Lesser Bear:

> The other, less in size, but valued more by sailors
> Circles with all her stars in smaller orbit.

The determination of position is more difficult than that of direction. Astronomical determination of position depends on the fact that, at any given instant, the heavens present a different aspect as seen from each different position on the earth's surface. Hence if this "aspect" can be measured, the position of the observer can be inferred. From the altitude of the celestial pole, or of the sun at noon, the latitude could be determined. The longitude, and hence the second co-ordinate of geographical position, remained the great unknown.

As astronomy through all these centuries made a definite contribution to the art of navigation, so it is not surprising that the need of more accurate navigation provided an incentive to the development of the science of positional astronomy. During the dark ages navigation made no advance; in fact, many of the charts of the fourteenth and fifteenth centuries were almost unbelievably inferior in concept and detail to the maps made over a thousand years earlier. With the reawakening of interest in maritime exploration, notably by the Portuguese under the genius and enthusiasm of Prince Henry the Navigator (1394-1460), the need of improved navigation became acute. Prince Henry collected much information on the problem, secured skilled astronomers, and founded an observatory at Sagres for the study of the apparent motion of the sun and other such material for improvement of navigation.

While the problem of determining latitude is very simple, it is interesting to note that even at the time of Columbus the latitudes of such well-known places as Malta were still being measured with errors of nearly two degrees, or over one hundred miles. Longitudes were little better than guessed; Columbus, arriving at islands off Central America, in longitude 70°W., thought he was in the (East) Indies, some 160° of longitude, or ten thousand miles, away. Maps of the Mediterranean of that time record the difference in longitude between London and Alexandria with an error of twelve degrees, or some five hundred miles.

Longitude is essentially determined by comparing the local time, say noon, with the time at some standard meridian, such as that of Greenwich. Local time could be fairly readily determined. But the determination of Greenwich time before the invention of portable mechanical time-keepers or radio, was difficult. As early as 1514, John Werner, of Nuremberg, had suggested that a standard

time could be determined astronomically by observing the position of the moon amongst the stars. While this idea was not practical at the time, owing to the poor knowledge of the motion of the moon, the scheme was brought forward again and again and finally was largely responsible for the founding of the great Royal Observatory at Greenwich.

In a Royal Warrant of Charles II, 1675, we read of the founding of this observatory:

> Whereas, in order to the finding out of the longitude of places for perfecting navigation and astronomy, we have resolved to build a small observatory within our park at Greenwich . . . according to such plot and design as shall be given you by our trusty and well-beloved Sir Christopher Wren, Knight . . . that you give order unto our Treasurer of the Ordnance for the paying of such materials and workman as shall be used and employed therein, out of monies as shall come to your hands for old and decayed powder, providing the whole sum shall not exceed five hundred pounds. . . .

The £500 from the spoilt powder was supplemented by wood from a demolished gate-house of the Tower of London, and metal and bricks from Tilbury Fort. The warrant for the payment of Mr. Flamsteed's salary included instructions to him to

> forthwith apply himself with the most exact care and diligence to the rectifying the tables of the motions of the heavens, and the places of the fixed stars, so as to find out the so-much-desired longitude of places for the perfecting of the art of navigation.

Tables of the moon's motion, and the method of "lunar distances" were developed sufficiently so that this method was actually put into use in navigation. The celebrated astronomer Maskelyne recorded positions by the lunar method, with an error of less than one degree, in contrast to what he described as previous uncertainties of ten to fifteen degrees. It might be here noted that even as late as 1740 the celebrated Admiral Anson, in trying to make the Juan Fernandez islands off the coast of Chile was so far off in his longitude measures that he sailed east instead of west, and the extra time involved caused the loss of many of his crew through scurvy.

That the lunar method was soon discarded was due to the development of a mechanical marine time-keeper, by Harrison. As early as 1598, Philip III had offered 100,000 crowns for a method by which the captain of a vessel could determine his position. In 1714 the British Government had offered a prize of £20,000 for determination of position within a half degree. It was for the latter

prize that Harrison competed, and was finally successful. His chronometer altered the whole problem of navigation. It should be remembered, of course, that his chronometer supplied only the Greenwich time; the local time, and hence longitude, and the latitude, had still to be determined by astronomical observation from ship-board.

The Royal Observatory has continued to fulfil the purpose of its foundation by aiding navigation. Since 1766 a Nautical Almanac has been published annually. The national observatories of other countries later developed similar almanacs. These volumes serve not only in navigation, but are the working tools of all astronomers. The Nautical Almanac is now supplemented by a "streamlined" Air Almanac.

We thus see that, in the past, navigation has aided in the development of astronomy, and, on the other hand, astronomical tables have made navigation possible. Astronomical methods, both for sea and air, have been radically improved and are supplemented by other methods which are of great importance.

The first of these is the method of pilotage and dead reckoning. By pilotage, whether sea or air, is meant navigation by means of bearings on observable landmarks. Dead reckoning (abbreviated from deduced reckoning) is the method of deducing position by keeping an account, or reckoning, of the course, drift, and distances from the last known position. This was the early method of navigation, and for coastal operations and for short air flights, is still the common method of air navigation. The difficulty with this method is that the landmarks may be invisible for long intervals, and the drifts due to wind or sea may not be determinable, and so the deduced position may be very incorrect in long journeys.

One of the celebrated feats of purely dead reckoning air navigation was Lindberg's transatlantic flight in 1927. Yet Weems, in his "Air Navigation" reports that Lindberg told him that "the fact that I might have been blown in any direction without knowing it preyed on my mind"—with the result that Lindberg supplemented his dead reckoning by astro-navigation and radio on all subsequent flights.

The second, and most modern, additional method of navigation is by means of radio bearings. For years radio has been used for correction of chronometers in navigation. Gradually the techniques

of radio broadcasting and reception have advanced to the extent that radio may be used either for "flying the beam" or for determining bearings of distinct invisible stations, just as in pilotage visual bearings on nearby points are taken. This is a very powerful method, and may be used in various ways to determine a definite position. Up until recently prominent authorities wrote that radio had completely replaced astronomical navigtion; that the latter was almost relegated to a hobby. The present emergency has, however, altered the picture. Greater altitudes of modern planes mean that clouds interfere much less with astronomical observation but more with pilotage than at lower levels; longer flights mean that radio beams become wider, and bearings less exact as the planes fly farther from their radio stations; radio fadeouts occur at inconvenient times; radio stations are frequently silenced during air raids; and the enemy can never be trusted not to misguide a pilot flying purely by radio. As a result, far more men are now learning the elements of astronomy and astronomical navigation that at any time in history.

Principle of Astronomical Navigation

The historical method of determining latitude and local time, and hence deriving longitude, has many disadvantages when applied to fast-moving ships or aircraft. It should be recalled that the cardinal points of the compass and hence the azimuth of any astronomical object is not normally accurately determinable, so that the only observation made is the altitude.

For any given instant of observation, the rotation of the earth or the celestial sphere may be neglected. Then each point on the earth has one definite point on the celestial sphere overhead, or in its zenith. Conversely, any particular point in the heavens has a corresponding point on the earth. Thus, at the given instant, each star has a "substellar point" on the earth. If the observer is at the substellar point of Vega, for example, Vega is exactly overhead, and the altitude of Vega will be measured as 90° above the horizon. Hence, at the given instant, an observer who found Vega exactly overhead would know his exact position on the earth. If observable identifiable stars were sufficiently plentiful so that one could always be found overhead, the determination of position would be simple. [The fact that it would require an infinite number of such stars, and

hence the observer could never learn the identifications, would, of course, detract from the practical use.] Failing this, we find that we measure the altitude of a bright star usually many degrees from the zenith. In practice stars too close to the zenith are unsatisfactory for observational reasons.

In figure 1 the resulting uncertainty of position is illustrated. Let A be the substellar point of Vega; at A Vega is in the zenith. An observer at B, whose zenith is at Z will find Vega at an angle ZBV, say 30° from his zenith. But this is exactly the angle BOA,

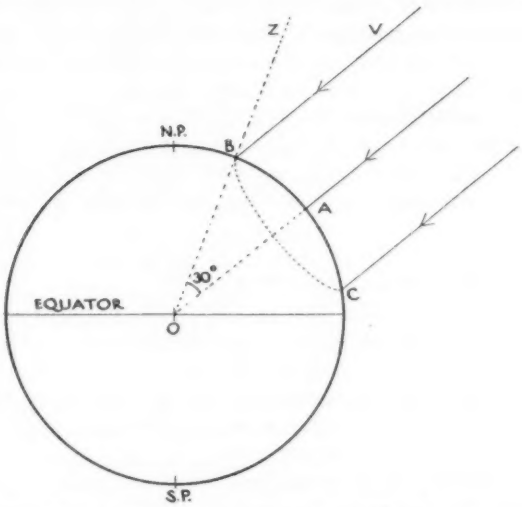

Fig. 1.—The thirty degree position circle of Vega.

the angle subtended at the centre of the earth by the distance BA (given all the rays from Vega are parallel). Hence $BOA = 30°$, and $BA = 2000$ miles, since the circumference of the earth, $360° = 24{,}000$ miles. Similarly, if an observer at C finds that Vega is 30° from his zenith, then C must also be 30 degrees or roughly 2000 miles from A. In fact, any observer 2000 miles from A will find Vega 30° from his zenith. If the only observation that can be made is the altitude of Vega, than all the observer knows is that he is 2000 miles from the substellar point of Vega, that is, that he is on a circle, with A as the

centre, and 2000 miles as the radius. Such a circle is a "circle of position."

Using a large terrestrial globe, the observer need then only find, for the given instant, the substellar point A, and with a pair of compasses swing a circle of radius equal to the observed zenith distance of the star. The observer is then on that circle. The circle

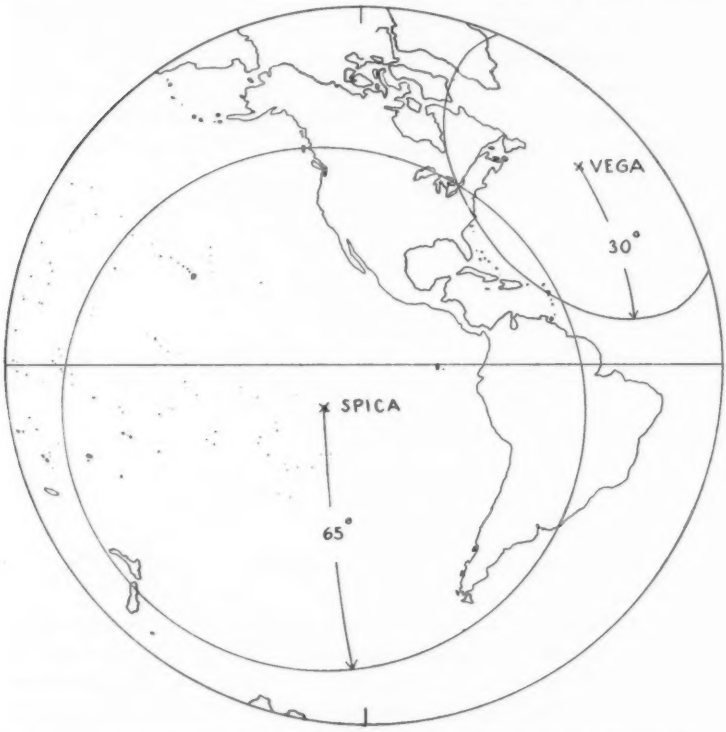

Fig. 2.—Determination of a "fix" from the intersection of two position circles.

is, however, usually many thousand miles in length. If he wishes to know his position more exactly, he observes the altitude of some other star, finds its substellar point, and draws a second circle of position at its zenith distance. As he must be on both these circles,

he must be on one of the two points of intersection. As these points of intersection will usually be hundreds or thousands of miles apart, he should know at which of the points he is situated! Thus with merely a globe, pair of compasses, and two observations, he can locate or "fix" his position. In figure 2, if an observer finds Vega has a zenith distance of 30°, and Spica 65°, at some specific time, he is either in Toronto or off Barbadoes, in the West Indies. He should know which!

This method requires a knowledge of the position of the substellar point of each star. Obviously, the latitude of the substellar point is exactly the declination of the star considered. The longitude of the point is constantly changing as the star moves from east to

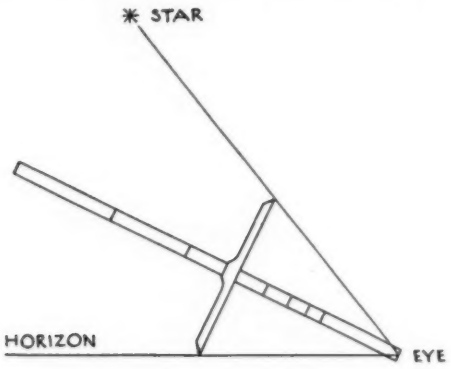

Fig. 3.—The Cross-staff.

west across the sky—or the earth rotates from west to east—beneath the stars. Thus the substellar point will move around a parallel of latitude, at the rate of one revolution a day. We need simply have a catalogue giving the longitude of the substellar point at midnight Greenwich time, and from the chronometer we know how much the earth has rotated since then. In this way, the longitude of the substellar point is found for any star at any time. The position circles and fix may then be found with respect to those substellar points.

While theoretically this is all that is involved in navigation, there are two outstanding practical problems that must be con-

sidered in some detail. The first of these is the actual measurement of the altitude or zenith distance of the star, and the second is the drawing of the position circles.

The Observation of Altitude

In early astronomy one of the chief instruments for measuring angles was the cross-staff. This instrument consisted of a cross-arm that moved along a graduated staff, always remaining at right angles

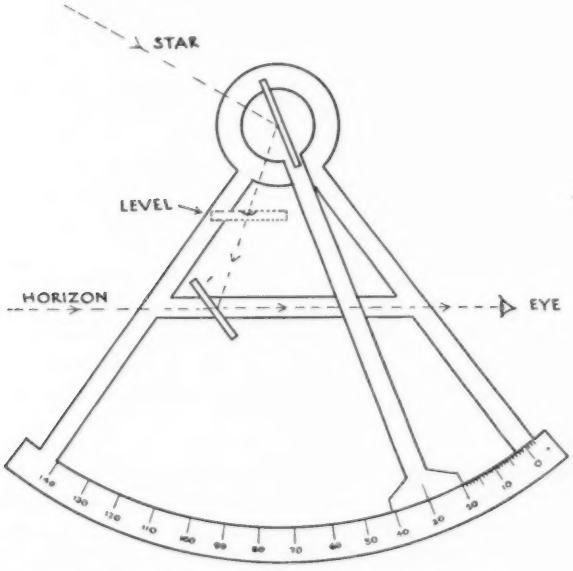

Fig. 4.—The Principle of the Marine Sextant, with level added.

to the staff. This is illustrated in figure 3. By sighting from the eye end of the staff to the two ends of the arm and moving the arm till the two ends just coincided in position with two stars, the angle between the stars could be measured. Similarly, by making one arm coincide with the sea horizon, and the other any given star, the angle between the star and the sea horizon was measured. This device was used by navigators in the 15th century. No substantial

improvement had been made in it in over a millenium. The great disadvantage was that the mariner had to look two ways at once—at the star and at the horizon.

In 1751, Hadley (and others independently) constructed an instrument from which our modern marine sextant has been developed. The principle is illustrated in figure 4. By means of a pair of mirrors, one a fixed mirror *H*, known as the horizon mirror, and the other an index mirror *I* movable through a measurable angle, the image of the star or other object is caused to enter the telescope. If then, the sextant is held vertically, and the telescope pointed towards the sea horizon, the image of the star may be made to coincide with that of the horizon. The coincidence will occur only when the index mirror is tilted at an angle which depends on the altitude of the star. This is read from the index scale. Since the mirror moves just half the angle, the scale is divided into half-degrees, which are marked as degrees. As long as the sea horizon is visible, the altitude may be measured. During the day the sun, and at times the moon, could be used. At twilight the stars and planets could be measured against the still visible horizon. But at night the marine sextant was useless once the horizon faded from view. Similarly, in aviation, the horizon is not suitable; it is often invisible or indistinct, and its position varies greatly with the altitude of the plane. This leads to the use of an artificial horizon. Gyroscopic horizons and mechanical horizons have been made but the generally used level is a spirit level.

The first bubble sextant is apparently to be attributed to Hadley. He attached a spirit level between the two mirrors. The star image was then made to coincide with the bubble; this then took the place of the invisible horizon. The directions called for a seaman standing alongside with a "lanthorn," shielded so that the bubble was bright enough to see, without hiding the star, or blinding the navigator. It is easy to imagine tense moments on a rolling ship as the poor seaman tried to fulfil these conditions!

A more convenient arrangement has been devised for use in the air. The scheme is illustrated in figure 5. The index mirror is indicated by *I* as before. For use with faint stars, *I* is made of unsilvered glass, and the observer looks through it at the star. The fixed "horizon mirror" *H*, now throws the image of an illuminated spirit bubble *B*, onto the mirror *I*, and thence to the observer's eye.

The observer need hence merely put the star image in the centre of the bubble, by moving the index mirror, and then reading the angle. Naturally in a moving plane, this is not too easy, and the average of many readings is usually made mechanically and automatically. While in practice the altitudes are affected by atmospheric conditions, acceleration of the plane, and even, at high-ground speeds, the rotation of the earth (the coriolis effect), very fair observations may be made by such an instrument. The modifications of the

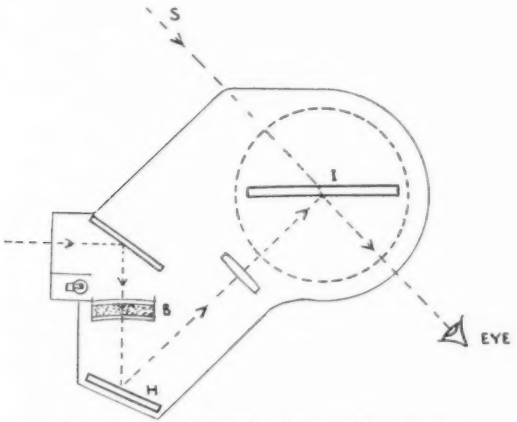

Fig. 5.—The Principle of the Bubble Sextant.

instrument and precautions needed in its use form an interesting study in themselves.

Determination of Position Circles and Lines

Having measured the altitude or zenith distance of some astronomical object we return to the problem of drawing the circle of position on the globe. While for demonstration purposes this may be done on a globe with compasses, it is obvious that this simple method is not practical for accuracy. If, for example, the desired scale is to be one millimetre of the globe equal to 1 mile on the earth, the globe must be over twenty-five feet in diameter. While conceivably such a large globe could be constructed and used for navigation and for the amusement of the passengers on the *Queen Mary*,

it would not be suitable in a plane. Therefore the sphere must be projected as a flat map or navigation chart. This means that the circles of position, when projected, cease to be circles; they can no longer be drawn with a compass; and their shapes must be computed.

Owing to the smallness of charts, the substellar point, usually some thousands of miles away, seldom appears on the chart. Also, as the navigator is supposed to have some idea of where he is, he need only draw a small part of the position circle, for the region in

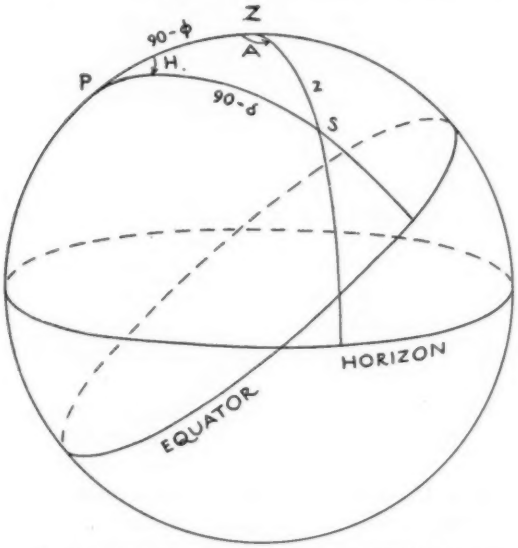

Fig. 6.—The triangle *ZPS* on the celestial sphere.

which his dead reckoning locates him. If only a small part of a very large circle is required, it can with little error, be considered a short straight line rather than a complicated curve. Such a straight line is called a "position line." While it had apparently been used earlier by various navigators this line is frequently called the Sumner Line, after Captain Sumner, who somewhat accidentally rediscovered the method, and gave it publicity over a century ago. The method consists of finding two points on the position circle and joining them by a straight line.

The way to find these points is by use of spherical trigonometry. In figure 6 is a representation of the celestial (or terrestrial) sphere. Here P is the pole, Z the zenith, and S the star. In the spherical triangle PZS the sides and angles are as follows:

$PZ = 90° - \phi = 90° -$ latitude of observer.
$ZS = z =$ zenith distance of the star.
$PS = 90° - \delta = 90° -$ declination of star.
$PZS =$ azimuth of the star.
$ZPS = H =$ hour angle of the star.

Sumner's method was to assume a latitude, ϕ_1, approximately correct. Then, using the measured zenith distance, z, the hour angle, H_1, and hence the longitude may be found by various equa-

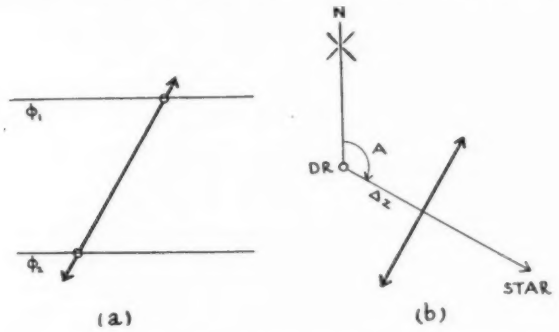

Fig. 7.—Derivation of Position Lines by method of Sumner (a) and St. Hilaire (b).

tions such as the fundamental (but not very convenient) astronomical formula

$$\cos H_1 = \frac{\cos z - \sin \phi_1 \sin \delta}{\cos \phi_1 \cos \delta}.$$

This means that, if an observer is at ϕ_1, and the zenith distance is z, then the hour angle must be H_1. This gives one point through which the position circle must pass. By choosing a second latitude ϕ_2, a second point on the circle is found from the same formula, and hence the position line, on which the observer must be, is located by joining these two points.

A much more rapid method, that of Admiral Marc St. Hilaire,

is the basis of all modern navigation. It is illustrated in figure 7. Here the navigator assumes he is at *DR*, his dead reckoning position. Then he computes what the zenith distance of the star would be, for an observer at *DR*. This may be given by the same formula, transposed into its more usual form:

$$\cos z = \sin \phi \sin \delta + \cos \phi \cos \delta \cos H$$

where δ, ϕ and H for *DR* are known. He also computes, or reads from a graph the azimuth A, or bearing, of the star. He knows then, that the star, as seen from *DR*, will be in the direction *S*. He takes the difference between the computed zenith distance (or altitude) with that observed. Let the difference be Δz. His position line does not then pass through *DR*, but through a point nearer or farther from the substellar points by a distance Δz. If the observed altitude is less than the computed, the observer is actually farther from the substellar point than is *DR*; if the observed altitude is greater, the observer is closer to the star (as in the diagram). He knows he is then on a small, almost straight, piece of the position circle. If a second star is observed, giving a second position line, he can "fix" himself at the intersection of these lines.

These methods require the solution of spherical triangles. This, at best, is a process requiring some minutes. At the speed of modern planes it is too slow. One way of simplifying the solution is to break the spherical triangle into two right-angled spherical triangles by drawing perpendiculars from *Z* to *PS* or from *S* to *PZ*. Then tables of the solutions of right-angle spherical triangles may be made up to avoid solving the general equations. One of the earliest of these short methods, since adapted with modifications by many others, was proposed by W. M. Smart. These methods involve much simpler computations, since the formulae for right-angle spherical triangles are simple compared with those for ordinary spherical triangles. The total tables required usually occupy only a few pages.

Naturally, instead of solving either the whole triangle at once, or as two right-angle triangles, a table could be constructed giving the actual solutions at close intervals for all possible triangles. Such tables, using various intervals, have long been in use. In practice the altitudes and azimuths are given for all values of the observer's latitude, for all values of the star's declination and hour angle. The St. Hilaire position line may be drawn immediately from these data.

The most complete of the tables is an excellent recently completed set, by the United States Hydrographic Office (H.O. 214). This, in a set of six volumes, contains solutions of some four million triangles. It eliminates all computation except easy interpolation, requires no knowledge of spherical trigonometry, and is of great use for marine purposes. It is rather bulky and detailed for use in aviation, though only the volume for the latitudes involved need be carried. A good way to reduce the size of the tables is to restrict the declinations to

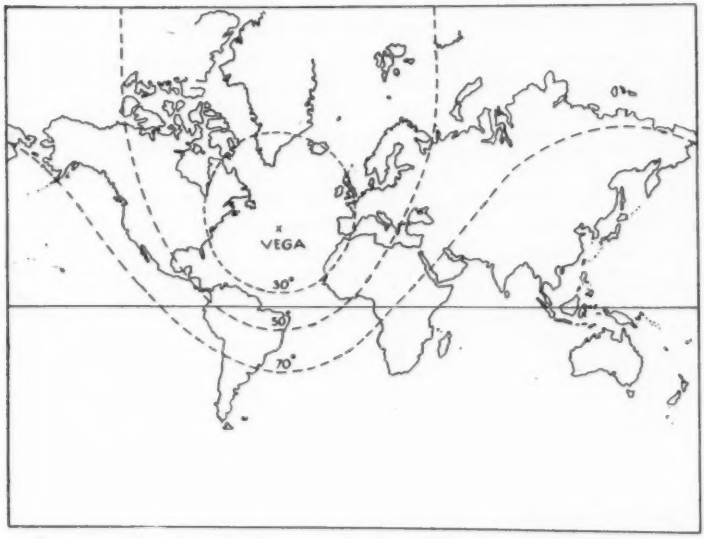

Fig. 8.—Projection of three circles of position onto a Mercator Map.

those of a selected list of bright navigation stars, rather than use a complete set of declinations.

Within the observational limits obtainable from planes, graphical methods are often sufficiently accurate and much more rapid than tabular methods. A very complete set of altitude curves is now published by Weems. Graphical methods, in other forms, have been drawn up by other workers, and are used in service navigation. The principle involved is very simple. In figure 8 a set of curves

of places for which Vega will have constant altitudes of 30°, 50° and 70° is projected onto a Mercator chart. The general shape of curves of equal altitude is illustrated. As the substellar point of Vega moves across the map once every twenty-four hours, these curves will simply be displaced parallel to the equator, at the rate of fifteen degrees each hour. Instead of making a single set of curves to cover the whole earth, a series of such sets for small ranges of latitude is made up. The larger scale permits drawing curves at much smaller intervals of altitude—for example for every ten minutes of arc, corresponding to ten nautical miles on the earth's surface. Such sets of curves may be drawn for the chief navigational stars; and the overlapping curves for two or three stars may be drawn on the same chart. Then, from the observed altitudes of two stars the intersection of the corresponding altitude curves (or position lines) may be found. Hence the latitude and longitude of the observer may be plotted directly on the navigational Mercator map. This method is very rapid, and hence particularly suitable for aerial navigation.

As well as tabular and graphical methods, numerous mechanical methods have been devised to facilitate navigation. Some of the better methods are, of course, in actual use in service flying, and hence not published at the present time.

The bibliography of navigation is very extensive. Apart from the excellent text-books which are not available except for official use, there are several good general reference books. The British Admiralty's *Manual of Navigation* (especially volumes I and II) treats sea navigation very fully and air navigation more briefly. Large modern editions of Nathaniel Bowditch's *American Practical Navigation* are published by the U.S. Hydrographic Office. *Air Navigation*, by Lt. Commander P. V. H. Weems (U.S.) is a very clearly written, practical handbook which can be most wholeheartedly recommended. *The Complete Air Navigator*, by D. C. T. Bennett, is also a good text-book on the subject. In all these, owing to the rapid improvements in navigation, the latest editions are far superior to the earlier.

David Dunlap Observatory,
Richmond Hill, Ontario.

PRESENTATION OF THE 1941 CHANT MEDAL TO H. BOYD BRYDON

By K. O. Wright

THE Chant Medal, first awarded in 1940, was founded by the Royal Astronomical Society of Canada to "stimulate increased effort in observation and research among the amateur astronomers of Canada". At the 1941 Fall meeting of the Council of the Victoria Centre it was unanimously decided to nominate H. Boyd Brydon as the most outstanding amateur in this district and the writer was instructed to draw up the nomination form, a summary of which follows:

H. Boyd Brydon was born in England and educated at Finsbury Technical College, London, where he was granted a diploma in electrical engineering. Most of his career was spent as a steam engineer in and about Chicago but, on retirement, he chose Victoria as his residence and at last found time to indulge in his desire to take up the study of astronomy. He bought the 4-inch Wray refractor from A. F. Miller of Toronto in 1931 and set up the Oak Bay Observatory, which has been available to all amateurs since that time. His observational programme has included the visual observation of variable stars and photographic observations of the sun and planets, and papers have been written for this Journal on "Nova Ophiuchi, No. 3", "Sketching Sunspots at the Telescope", and "The 1940 Transit of Mercury".

Mr. Brydon's experience as an engineer interested him in the design and construction of astronomical instruments and this, combined with his great desire to increase telescopic observations among laymen, led to a series of papers in the Journal which particularly stressed the application of simple tools and materials within the reach of the average amateur. These titles included "Telescope Mountings for Amateur Builders", "The Small Observatory and its Design", "Inexpensive Drives for the Small Telescope", and, most recently, "A Yoke Mounting for the 6-inch Reflector". These papers not only gave a brief history of mountings and designs but gave detailed plans for their construction which any person who had constructed a mirror could easily follow.

These contributions were a direct result of Mr. Brydon's interest in astronomy and his overwhelming desire to make the wonders of the heavens available to as many persons as possible. This energy also found an outlet in several other forms.

Numerous radio broadcasts were given by Mr. Brydon over the local Victoria station, five of which have been printed in the Journal, with the object of directing the attention of all listeners to the science of astronomy.

Six other papers on general astronomical matters have appeared. One of these, "Visual Photometry of Variable Stars", running to 64 pages, showed how anyone with either field glasses or a small telescope could perform work of great scientific value, and gave a review of the various methods and instruments employed in this study. Another, "Popularizing Astronomy", appealed to everyone with a real love of astronomy to spread his interest and knowledge in order to increase the numbers of amateur astronomers in Canada and elsewhere.

But, while articles reach thousands of readers, they often seem impersonal and it is personal contact which really inspires an interest in any hobby. The great increase in activity among amateur astronomers in Victoria during the past ten years can be directly traced to the work of Mr. Brydon. All regular members of the Society fell under his spell and the many telescopes which have since been constructed testify to his influence. In addition to his work with the Society, that large body of the public who are interested in the sky but who do not know that an astronomical society exists were reached through press and radio and hundreds have been attracted by the lectures and opportunity for observations at the annual course of "Summer Evenings with the Stars"—a series designed to give the laymen an outline of the objects of interest in the heavens and a brief, simple explanation of their movements. This series was started by Mr. Brydon ten years ago when a few persons gathered at his Observatory and each year since then the attendance and public interest have increased.

These achievements of Mr. Brydon have long been appreciated by his friends in Victoria and it was with great pleasure that they learned that he had been honoured by the General Council with the award of the 1941 Chant Medal as announced at the Annual General Meeting of the Society.

Presentation of the Chant Medal to H. Boyd Brydon was made at the regular meeting of the Victoria Centre on February 18, 1942. The President, Dr. R. M. Petrie, first expressed his pleasure on behalf of all those present that this great honour had come to Victoria. and then called on Mr. Gordon Shaw, the Honorary President, to formally present the medal to Mr. Brydon.

In making the presentation, Mr. Shaw remarked:

Two years ago the Royal Astronomical Society of Canada announced that it was prepared to award each year a silver medal as signal recognition to Canada's most outstanding amateur astronomer of the year. Centres of our Society throughout the Dominion sent their nominations for consideration by the committee for the award of the Chant Medal—so named in honour of Dr. C. A. Chant, for many years professor of astronomy at the University of Toronto, now professor emeritus and director emeritus of the David Dunlap Observatory, and with some fifty years of astronomical research to his credit.

When members of this Centre's Council met to consider their nomination for the 1941 medal, their task was an easy one. Our chosen nominee had

written voluminously for the JOURNAL; he had developed in detail an excellent equatorial mounting, complete with setting-circles for the amateur mirror maker; and he had generally furthered the cause of Astronomy as a hobby. The nominee was, of course, our former secretary and president, Mr. H. Boyd Brydon.

In accordance with our expectations, Mr. Brydon's contribution to amateur astronomy was recognized by the committee and, as a result, we received notification about a month ago that this honour had descended upon our fair city.

Perhaps I may be permitted a few personal remarks. Having served under Mr. Brydon as secretary of this Centre during his term as president, I know very well that his devotion to the celestial science knows no bounds and because of the delight and satisfaction he received in his pursuit of the heavenly Muse he was spurred to inoculate his fellow man with this enthusiasm—hence his dynamic work in this Centre and his numerous constructive articles written for the JOURNAL.

This honour has been appreciated not only by our members here but by the Society as a whole. Dr. F. S. Hogg, the president of the Royal Astronomical Society of Canada, has written to Mr. Brydon, and I shall read an excerpt from this letter: ". . . Not only in my official capacity do I send you greetings but also as an old friend and as an editor of the JOURNAL, to which you have contributed so much, do I rejoice in this well deserved award. I think that we are fortunate to be able to make this award to so worthy a candidate, for the purpose and prestige of the Medal . . ."

Mr. Brydon, I am most honoured, on behalf of the Royal Astronomical Society of Canada, to present to you, Sir, this, the Chant Medal, for your meritorious work in the year of 1941.

In accepting the medal, Mr. Brydon made the following reply:

I am deeply grateful for the honour the Society has done me in presenting to me this Chant Medal accompanied by so flattering a citation. Recognition of one's work by one's peers adds to the pleasure of doing it the assurance that it is not wasted. When that recognition comes, as it comes in this instance, from one's astronomical pastors and masters it is doubly pleasant to receive.

As you know, Victoria is the second Centre to count a Chant medallist among its members. It rests with us whether the time shall be short or long before Victoria again has that honour. The honour will not come, it cannot come, unless we take an active interest both in the Centre itself and in the astronomical work which it can do. The officers and council of the Centre, I assure you, are doing everything in their power to promote its well-being but they need and should have our active co-operation. We owe to them, to it and to ourselves to bring to it as many new members as we can. Membership must mean to us doing, not merely listening to lectures.

We have a splendid section engaged in making themselves excellent telescopes under the directorship of Mr. W. R. Hobday and now, if you will allow me to say so, we have an excellent mounting for these mirrors. But that is not

enough. We need an active observing section whose members will do more than look into the eyepiece of a telescope and say "Oh, how wonderful". The lack of a telescope is no excuse. There is much astronomical work that, given good health, we can do for which we need no instrument but the will to do it. Let me give you very briefly a few examples:

Nova Search: It is of great importance that news of the outburst of a Nova reach our observatories at the earliest possible moment. To this end, amateur bodies throughout the world are co-operating. All that is needed is that the observer, on every clear night he is able, should examine carefully a particular area of the sky and assure himself that no stranger is among the stars that inhabit it. The area is quite small—a square with sides about twice the distance between the pointers to the North Star.

Other work not requiring a telescope is the observation of meteors, of aurorae and of certain bright variable stars.

Research: There is the opportunity of research, to determine errors due to the observer's eye, to the effect of colour, to the relative position of a variable and comparison star, and to determine the best method of observing variables, whether by a prolonged look or by a quick glance. Work on such subjects as these can be done with artificial stars and is sorely needed.

Astrology: There is also the fight against astrology. Some of you may have read the recent article in *MacLean's Magazine* on the evil being wrought by this wicked pretence to foretell events. It is not only wicked but stands self-condemned as powerless to do what it pretends. It is of record that in England the principal astrological society and the leading astrological periodical both have quit for the duration; the one because its members could not agree as to what the stars foretold, the other "Because the future was so uncertain". I submit to you that as members of the Royal Astronomical Society of Canada, individually and collectively, we do what we can to destroy this evil.

I thank you sincerely, Ladies and Gentlemen, for the kind manner in which you have shown your approval of the decision of the Chant Medal Committee for 1941.

After prolonged applause had testified to the hearty approval of the audience in this award, the meeting continued with an address by Lt. Commdr. H. R. Tingley on "Ships and Stars". At the close of the meeting Mr. Brydon very kindly allowed the members to examine and admire the medal.

Dominion Astrophysical Observatory,
February 23, 1942.

MINUTES OF THE ANNUAL MEETING OF THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

The Annual General Meeting of the Society was held in the McLennan Laboratory of the University of Toronto on January 13, at 8 p.m. The chair was taken by Dr. F. S. Hogg, the President.

The minutes of the last Annual Meeting having been published in the JOURNAL, were taken as read and adopted.

Mr. J. H. Horning, General Treasurer, presented his report. This showed a balance on hand at the end of the year of $96.00, with $561.00 outstanding accounts not yet paid. There is on hand, and paid for, an inventory of publications for sale valued at $525.00. The report, which will be printed in the JOURNAL (see page 113), was adopted.

The General Secretary, Mr. E. J. A. Kennedy, in his report drew attention to the fact that the membership during the year had shown a decrease from 918 to 886—a result not unexpected in wartime. He spoke of the value of the Society's publications and expressed the conviction that they should not be curtailed. The death-roll for 1941 included Dr. J. S. Plaskett, formerly Director of the Dominion Astrophysical Observatory at Victoria, Mr. R. H. Combs, the Society's Recorder, Mr. J. E. Maybee, who was active in the Society as far back as 1896.

The thanks of the Society were accorded to the officers for their services during the past year.

The President made mention of the organization of a group of interested people in the city of Quebec, and the desire was expressed that they should become a Centre of the Society. Correspondence is being carried on with this in view.

In the absence of Dr. Millman on military service, the report of the Librarian was given by Dr. D. W. Best, Acting Librarian. During the year 59 periodicals were received from countries within the British Empire, 150 from the United States and 39 from other countries,—248 in all. No new books were added to the library by purchase. The report was adopted.

Mr. R. S. Duncan, Curator, stated that the Society's lantern slides were being overhauled, and that some of the telescopes also required attention. Discussion took place about the use of tele-

scopes by the Army for coast guard defence and in the navigation schools, and one or two of the members present offered assistance in this respect.

Miss E. M. Budd and Mr. F. L. Troyer were appointed Scrutineers. They reported 153 good ballots cast, and announced the following duly elected as Officers for 1942:

Honorary President—The Hon. Duncan McArthur, Ph.D., Minister of Education for the Province of Ontario.

President—F. S. Hogg, Ph.D., Toronto.

First Vice-President—Miss A. Vibert Douglas, Ph.D., Kingston.

Second Vice-President—A. E. Johns, Ph.D., Hamilton.

General Secretary—E. J. A. Kennedy, 198 College Street, Toronto.

General Treasurer—J. H. Horning, M.A., Toronto.

Recorder—H. W. Barker, Toronto.

Librarian—P. M. Millman, Ph.D., Toronto.

Curator—R. S. Duncan, Toronto.

Council—D. S. Ainslie, Ph.D., Toronto; N. H. Broadhead, Hamilton (deceased, Jan. 28, 1942); S. C. Brown, Toronto; H. Boyd Brydon, Victoria; J. W. Campbell, M.A., Ph.D., Edmonton; Rev. W. G. Colgrove, London; Dean H. F. Hall, Montreal; E. A. Hodgson, M.A., Ph.D., Ottawa; H. P. Newton, Vancouver; Miss F. Shirley Patterson, Ph.D., Toronto; Andrew Thomson, M.A., Toronto; L. A. H. Warren, M.A., Ph.D., Winnipeg.

The Auditors, Mr. Andrew Thomson and Mr. F. L. Harvey, were thanked for their services and were re-appointed for 1942.

A vote of thanks was also tendered to Dr. Chant, Editor, and Dr. Hogg, Assistant Editor, and to the Associate Editors of the JOURNAL and the HANDBOOK; also to Miss Ruth J. Northcott and Dr. Shirley Patterson for their valuable aid.

H. W. BARKER, *Acting Recorder*

REPORT OF GENERAL SECRETARY FOR 1941

The membership of the Royal Astronomical Society of Canada shows a decrease of 32. This decrease is not due, we are sure, to a lack of interest in the subject of astronomy, but because of the war; resignations on account of pressure of work and enlistments have reached the office, and a number of members in the conquered countries of course could not renew their subscriptions.

The conflict has affected many of our activities, not the least cause of restriction of them being the absence of Dr. Millman, Dr. Ainslie, Dr. Heard and others, whose technical knowledge is now of such great value to the Government in our war effort. Together with the University of Toronto, which has loaned the services of these specialists for the duration of the war, the Society can take justifiable pride in their contribution to the cause of freedom.

Our publications are in considerable demand, thus enhancing the prestige of the Society. During the year, under the sponsorship of Mr. Andrew Thomson, the series of articles by Dr. B. Haurwitz (reprinted from the JOURNAL) on the Physical State of the Upper Atmosphere, was brought up to date by the addition of another chapter by the author. A new edition of 1500 copies was prepared. As this is one of the most important brochures on the subject published anywhere it has found a place in many of the universities and camps of instruction of the United States as a text book. It is of particular value in these days to meteorologists and instructors in aeronautics. The cover is much improved over the old reprint and the price is low; it could not be produced to sell at such a price (75 cents) were it not for the free contribution of time and services by the author and editors.

The OBSERVER'S HANDBOOK is still the most useful and popular publication of its kind on the market; and 3,000 copies have been printed for 1942.

The Chant Medal, which is awarded yearly to the amateur astronomer whose work has been judged the most meritorious, was won by Mr. H. Boyd Brydon, of Victoria, B.C.

Death has again made much regretted gaps in our membership. The period 1940-1941 has been the most severe in this respect of any two years in our history. The scientific world in general shares with us the loss of one of its most distinguished astronomers, J. S. Plaskett, who died October 17, 1941,—the late Director of the Dominion Astrophysical Observatory, Victoria, B.C. The long list of scientific awards earned and the many honorary degrees conferred upon him indicate clearly the high place he occupied in the world of astronomy. His achievements brought honour and fame not only to himself but also to his country and the Royal Astronomical Society of Canada.

The Council particularly felt the passing, on April 21, 1941, of R. H. Combs, who for some years was the Society's Recorder. He was a man of many talents and distinguished himself in the engineering field.

J. E. Maybee, a past Treasurer of the Toronto Centre, died on August 1, 1941. His long membership dates back to 1896. He was quite active in the affairs of the Society in its early years.

The details of the membership by Centres follow.

MEMBERSHIP ON DECEMBER 30, 1941

	1940	*1941*
Toronto Centre	188	190
Montreal "	91	80
Winnipeg "	45	33
London "	47	37
Edmonton "	45	46
Hamilton "	54	57
Vancouver "	38	36
Members at large	228	224
Ottawa Centre	60	60
Victoria "	107	109
Life Members not in Centres	15	15
Totals	918	886
Additional subscribers to JOURNAL	60	62

E. J. A. KENNEDY, *General Secretary.*

REPORT OF THE LIBRARIAN

During 1941 the following periodicals were received:

From Canada and the Empire	58
" The United States	150
" Other Countries	39
Total	248

In addition the Harvard Announcement Cards were received. Books loaned from the shelves during the year numbered 146. Expenditure on binding, etc., $52.83.

While no new books were added to the Library by purchase in 1941, the following new books will be placed on the shelves early in 1942:

The Milky Way by Bart J. Bok and P. F. Bok.
The Story of Variable Stars by L. Campbell and L. Jacchia.
Between the Planets by F. G. Watson.
Earth, Moon and Planets by F. L. Whipple.
Handbook of the Heavens by H. J. Bernhard and Dorothy A. Bennett.
Webb's Atlas of the Stars.
John Alfred Brashear by Harriet A. Gaul and Ruby Eiseman.
The Soul of the Universe by Gustaf Strömberg.
Introduction to Meteorology by S. Petterssen.
The Morning Star rises, an account of Polynesian Astronomy by Maud M. Makemson.
Starcraft by Wm. H. Barton and J. M. Maron.
Birth and Death of the Sun by Geo. Gamow.

P. M. MILLMAN, *Librarian.*
per D. W. BEST, *Acting Librarian.*

REPORTS OF THE SECRETARIES OF THE CENTRES

TORONTO CENTRE

Meetings. During the year 1941 there were held 2 Council meetings, 11 regular meetings and one outdoor meeting. The attendance was exceptionally good, it being frequently necessary to move into a larger room.

February 4—Mr. W. A. Ladd, M.A.: "The Electron Microscope."
February 18—Mr. J. R. Gibbs: "Amundsen's Conquest of the South Pole."
March 4—Mr. J. R. Collins: "The Border-land of Physics and Astronomy."
Mr. G. F. Longworth: "Why does an Observatory need a Machinist?"
March 18—Prof. A. T. DeLury, M.A., LL.D.: "The role of Mathematics in Astronomical Discovery."
April 1—Amateurs' Night, Mr. Bertram J. Topham: "Pleasures derived from a systematic amateur's programme."
Mr. Jack Grant: "An Amateur's Astronomical Photography."
April 15—Mr. E. J. A. Kennedy: "Light-absorbing material and Dark Stars."
Mr. A. F. Bunker: "Small stars of Great Density."
Miss Ruth J. Northcott: "Stellar Evolution."
April 29—Open-air meeting.
October 7—Prof. H. R. Kingston, Ph.D.: "The Way of the Moon."
October 21—Mr. G. F. Longworth: "Aluminizing Chamber for the 74-inch Mirror."

November 4—Dr. Florence Quinlan: "Waves in Light and Sound."
November 18—Mr. W. T. Patterson, R.O.: "Telescope Construction and Mirror Testing."
December 2—Dr. F. Shirley Patterson: "Other Milky Ways."

The popular courses of short lectures were continued at the Spring meeting by the following members:

Mr. J. R. Collins: "Stellar Classification."
Mr. T. D. Waring: "Binary and Multiple Stars."
Mr. W. T. Patterson: "Pulsating Stars and Novae."

with the three mentioned above under the date April 15.

At the autumn meetings at 9.15, Dr. Helen S. Hogg gave a course on "Explorations of Clusters and Nebulae." At the close of each meeting Dr. Hogg made available mimeographed copies containing a summary of the lecture, as did former lecturers, a feature warmly appreciated by the members.

Membership. As of December 31, 1941, there are 190 members on the roll, of whom 8 are life members. There were 16 new members elected and 14 removed for various reasons, leaving a net gain of 2. Among the names of members removed by death we record with regret those of Mr. J. E. Maybee, a former Treasurer of this Centre, and Mr. R. H. Combs, lately Recorder of the General Society.

Observations. The Centre is organized for work through five committees: 1. Variable Stars and Novae. 2. Meteors, Fireballs and Meteorites. 3. Sun, Moon and Planets. 4. Comets and Asteroids. 5. Making and care of Telescopes.

Any member may register with the director of the section or sections in which he is interested. The director will then plan an observation programme for him and receive monthly reports on progress.

The Centre, in co-operation with the Canadian National Exhibition, placed a telescope in Exhibition Park with two volunteer members in charge every evening during the period of the exhibition. Great numbers of visitors availed themselves of the opportunity to look at objects in the sky through a good telescope. Mr. F. L. Troyer took charge of a Red Cross contribution box in which star-gazers who wished to offer something placed their gifts;

these donations to the Red Cross Society amounted to something over $70.00.

Presentation. At the first autumn meeting Mr. H. G. Duncalfe presented to the Centre a skilfully hand-made gavel. The centre part of the head is a sphere made of walnut so selected that one half is light in colour, the other dark. Around this sphere runs a raised band representing the Zodiac in which the signs are inlaid in brass. The gavel is provided with a neatly made case bearing on its top the letters R.A.S.C.

Constellation Study. A group for the study of constellations has been formed under the direction of Miss Ruth J. Northcott, M.A.

Telescopes. A number of members possessing telescopes have offered to make them available for viewing celestial objects to persons living in their vicinity.

F. L. HARVEY, *Secretary.*

OTTAWA CENTRE

There were no regular meetings of the Ottawa Centre during the year, though several talks were given to local organizations by various members.

This fall a Junior Club was organized with regular fortnightly meetings held at the Observatory. Average attendance to date has been 20.

There were three council meetings.

Membership remains at 60, there being a loss and a gain of four. It is known that at least four from the Centre are in the army.

Observations were restricted this year, photographic and visual observations of the Perseids being carried on at the Observatory only. Observations were also planned for the Leonids, but the weather was not very favourable.

Correspondence includes one News Letter to the membership concerning Cunningham Comet. Also a weekly column to one of the local papers was maintained under the title of "Sky Facts."

As in the past, and through the courtesy of the Dominion Astronomer, the Saturday Evening Programme Bulletin of the Dominion Observatory was sent to all members. Observatory star charts have also been available upon request.

MALCOLM M. THOMSON, *Secretary.*

Hamilton Centre

This Centre held eight regular meetings and one field night.

January 2—W. D. Stewart, C.O.T.C.: "What is in our Universe?"
February 6—G. E. Campbell, M.A.: "The Instability of Planet Earth."
March 6—A. E. Johns, M.A., Ph.D.: "Time," with illustrative slides.
April 3—T. H. Wingham, B.A.Sc.: "A Word about the Moon."
J. R. Collins of Toronto: "Atoms and Stars," with illustrative slides.
May 1—J. R. Gibbs: "An Amateur Astronomer goes lecturing."
May 30—Field Night at the residence of W. T. Goddard.
October 2—Entertainment Night: Observations by W. D. Stewart and E. E. Bossence; Query contest conducted by Dr. Wm. Findlay and T. M. Norton; Historical Astronomy by F. H. Butcher, B.A., assisted by N. H. Broadhead; Vocal selections by Madame Jean Stewart, accompanied by Emlyn James; Refreshments served by the wives of the Executive at this meeting.
Nov. 6—G. A. Wrenshall, M.Sc., Ph.D.: "New Worlds within the Atom."
December 4—Norman Green: "A Universe of Colour."

This was the annual meeting, with election of officers. The meetings during the year were very interesting, due to the able chairmanship of N. H. Broadhead, who is an innovation expert. The December meeting was manned by the young men members, Chas. Mason in the chair. All lectures during the year were preceded by a curtain-raiser. The enrolment of the Centre is now 57.

James R. Graham, *Secretary-Treasurer.*

Winnipeg Centre

During the year 1941 the Winnipeg Centre held eight regular meetings as follows:

January 8—"Comets": Prof. L. A. H. Warren.
February 12—"Cosmic Rays": Prof. W. A. Anderson.
March 12—"The Planetarium": Mr. V. C. Jones.
April 9—Members' Night. Mr. R. S. Evans: "Astronomical Observations from the Standpoint of the Amateur";
Messrs. L. J. Crocker, H. E. Riter, and W. P. Johnson: "A Symposium on Meteorology".
May 14—"Transmission of Energy": Monsignor T. W. Morton.
October 8—Social Evening: C.P.R. Scenic and War Films.
November 12—"Air Navigation": Squadron Leader A. H. Gillson.
December 10—"The Age of the Earth": Mr. L. W. Koser.

Seven of these meetings were held in Theatre "F" University Buildings, and the social evening in Rupert's Land Girls College. All meetings were open to the public, except the social evening, which was for members and friends only. The average attendance was 43.

During the year four members resigned, due to lack of time and pressure of work and other activities; three others left the city, and six were dropped from the list. One former member rejoined, and two nominations were placed before the December meeting. The membership is now thirty-three.

Owing to the uncertainty of weather conditions no observation night was arranged, but reports indicate that every opportunity was taken by individual members to use their telescopes when possible.

MARGARET E. WATTERSON, *Secretary.*

VICTORIA CENTRE

Membership. In January 1941 the membership list contained 107 members—3 life, 96 regulars, 8 juniors. During the year 18 members were lost for the following reasons: 2 deceased, 2 transferred to other centres, 5 resigned, 10 dropped for non-payment of fees. This policy of dropping members in arrears has been followed by the Council for several years since these persons are effectively a burden to the Society. During the year 1941 20 new members were enrolled so that the present membership stands at 109, these being divided as follows: 3 life members, 10 junior, 96 regular, making a total of 109.

Meetings. During the year 20 meetings were held: 9 regular meetings, 5 Council meetings, 6 special summer course meetings. The usual high standard of lectures has prevailed throughout all regular meetings, topics including not only astronomy but also a wide range of other allied subjects. Council meetings were held for the purpose of arranging programmes and carrying on the general business of the Society.

Summer Course. The Summer Course this year registered 20 members but the attendance at each of the meetings averaged close to triple that number. The low registration at the Summer Course in no way indicates a falling off in the popularity of this

feature, since many who attended the Summer Course registered as new members of the Society rather than as temporary Summer Course members.

Lectures to the Forces. Lectures to the forces were continued at the Y.M.C.A. Hut at Macaulay, members of the Council offering their services for this feature which proved very popular with the men of the forces.

Conclusion. The Secretary is expressing the feeling of the entire Council in stating that the year 1941 was a most successful one for the Victoria Centre of the Royal Astronomical Society of Canada. It is felt that the mental relaxation and enjoyment offered by this Society is highly desirable at the present time, and it is hoped that the future year may bring continued success to this Centre.

PHOEBE RIDDLE, *Secretary.*

LONDON CENTRE

During the year 1941 the London Centre held 8 regular monthly meetings with a total attendance of 236. At each meeting Mr. E. H. McKone discussed items of current astronomical interest and Dr. Kingston directed a study of the OBSERVER'S HANDBOOK. Other details of the separate meetings are as follows:

January 10—Rev. W. G. Colgrove: "The New Cronyn Telescope—Its Internal Secrets Exposed and Demonstrated Graphically." Attendance 22.

February 14—Dr. H. R. Kingston: "Where is our Wandering Moon Tonight, and Why?" Attendance 24.

March 14—Mr. O. Kilburn: "Lenses and Mirrors for Astronomical Work." Observations through the Cronyn telescope. Attendance 33.

April 18—Mr. T. C. Benson: "The Properties and Applications of the Pendulum." Observations through the Cronyn telescope. Attendance 31.

May 9—Dr. F. S. Hogg: "Variable Stars." Observations with telescopes. Attendance 40.

June 7—Annual Picnic (in conjunction with a Regional Gathering of the Federation of Ontario Naturalists).

October 10—Dr. G. R. Magee: "Mysterious Mars." Observations on Mars and other planets. Attendance 29.

November 14—Dr. E. G. Pleva: "Weather Proverbs." Attendance 28.

December 12—Annual Meeting: Reports of Secretary and Treasurer; Election of officers for 1942; Entertainment and Refreshments. Attendance 29.

The paid-up membership on this date (December 12, 1941) is 37.

The Centre lost a valued friend and benefactor this year in the death of Mr. E. E. Reid. Through Mr. Reid this society enjoyed for many years the free use of a room in the new London Life Building. Also due to his influence the Directors of the London Life Insurance Co. purchased the Dresden Meteorite and case for our Observatory.

R. H. COLE, *Secretary-Treasurer.*

EDMONTON CENTRE

There have been two Council meetings during the year, at which the programme subjects and speakers were arranged, and other essential business carried on.

Seven regular meetings have been held in Room 142 of the Arts Building, through the courtesy of the University authorities. The annual meeting took the form of a dinner in the Corona Hotel, as usual. The average attendance was 27 members and visitors.

The talks on the HANDBOOK were given by Mr. Wates, who is our most active member. Occasionally there were short talks on constellations, or demonstrations of simple principles by other members. A list of the main speakers and their subjects follows:

December 1940—Mr. C. G. Wates: "Meet the Family."
January 1941—Miss Jean Wallbridge: "Comets."
February—Mr. G. W. Robertson: "The Canadian Weather Service."
March—Mr. Robt. Chambers: "Primitive Astronomy."
April—Mrs. G. A. Clarke: "One Day Telleth Another"—book review.
May—Dr. E. H. Gowan: "Photography in Astronomy."
October—Mr. H. R. Leaver: "Isaac Newton."
November—Dr. J. W. Campbell: "Milky Way Slides."
Dr. E. H. Gowan: "Navigation."

The various factors managed to combine adversely, and as a result it was not possible to arrange for a picnic.

The roll of the Centre consists of 46 regular members (7 of whom live out of Edmonton), and 4 associate members.

E. H. GOWAN, *Hon. Secretary.*

VANCOUVER CENTRE

The past year has been a very successful one for the Vancouver Centre of the R.A.S.C. A well balanced programme of addresses

on vital topics was enjoyed by members and their friends during the year.

The programme for 1941 opened with an interesting lecture by Dr. George Volkoff of the Physics Dept. of the University of B.C. on the topic "Novae and Supernovae". This was followed in February by an instructive talk on "Aviation" by Stanley Burke of the Boeing Aircraft Company. The Society was fortunate in obtaining two members of the University Staff as speakers for the March and April meetings. Dr. J. M. Keller of the Physics Department chose as his topic "The Measurement of Interstellar Distances", while Dr. S. A. Jennings of the Department of Mathematics discussed "Mathematics Without Numbers".

The annual dinner held in May proved to be a very enjoyable function. The members were favoured by a very interesting talk on "The Sun, a Variable Star", by Mr. R. A. McCauley of the Dominion Meteorological Service.

The opening meeting of the eleventh season of the Centre, held in October, was featured by a very instructive lecture on "Sundials" by Mr. N. D. Blagdon Phillips. At the next meeting the Honorary President of the Centre, Dr. J. A. Pearce, Director of the Dominion Astrophysical Observatory at Victoria gave an outstanding lecture before a large audience. His well-illustrated discourse dealt with the topic "Some Applications of the Radial Motions of the Stars".

The speaker scheduled for the December meeting was Mr. Howard Edwards of the Dominion Meteorological Service of Canada, who had chosen "Airline Weather Conditions over the Rockies", as his subject. Unfortunately, at the last moment, the proclaiming of a blackout necessitated the cancellation of the meeting and the postponement of Mr. Edwards' address to some future date. The election of officers for 1942 was moved forward to the January meeting.

The meetings held during the year were uniformly well attended and the monthly notice mailing list reached a figure of sixty-one. The paid-up membership also showed a very substantial increase over the number for the previous year.

H. D. Smith, *Secretary.*

FINANCIAL STATEMENT, 1941

I. GENERAL TREASURER

GENERAL ACCOUNT No. 4359

Receipts		Disbursements	
Balance from 1940	$1,353.78	Publications	$3,746.39
($112.30 belongs to Southam Press Fund)		Public Meetings	63.70
Grants received	2,120.00	Library	52.83
Fees	1,433.50	Stamps and Stationery	282.20
Publications	896.34	Salary Assist.-Treasurer	780.00
Interest	146.75	Grants to Centres	558.00
Miscellaneous	18.24	Rent	120.00
Bond repayment (S.P.Fd.)	1,000.00	Janitor	18.00
		Chant Medal Dies	157.92
		Miscellaneous	57.82
		Balance to 1942	1,131.75
		($1,036.08 belongs to Southam Press Fund)	
Totals	$6,968.61		$6,968.61

LIFE MEMBERS' ACCOUNT No. 4390

Receipts		Disbursements	
Balance from 1940	$ 95.67	Bank balance to 1942	$ 121.15
Bank Interest	.48		
Life Members' fees	25.00		
Totals	$ 121.15		$ 121.15

BUILDING FUND ACCOUNT No. 4383

Receipts		Disbursements	
Balance from 1940	$ 242.17	Balance to 1942	1,454.89$
Bank Interest	1.59		
Bond Interest	211.13		
D. of C. Bond repayment	1,000.00		
Totals	$1,454.89		$1,454.89

SOUTHAM PRESS FUND

(Cash Balance deposited in General Account 4359)

Receipts		Disbursements	
Balance from 1940	$ 112.30	Chant Medal Dies	$ 157.92
Bank Interest	.70	Balance to 1942	1,036.08
Bond Interest	81.00		
D. of C. Bond repayed	1,000.00		
Totals	$1,194.00		$1,194.00

SUMMARY OF BONDS AND DEBENTURES HELD FOR R.A.S.C. BY IMPERIAL BANK

Account	*Brought Fwd.*	*Matured*	*Carried Fwd.*	*Yearly Int.*
Life Members	$ 650.00	.....	$ 650.00	$ 22.80
Building Fund	5,650.00	$1,000.00	4,650.00	211.13
Southam Press Fund	1,900.00	1,000.00	900.00	81.00
Totals	$8,200.00	$2,000.00	$6,200.00	$314.93

Audited and certified correct.

ANDREW THOMSON, *Auditor.*
F. L. HARVEY, *Auditor.*

(Signed) J. H. HORNING,
General Treasurer, R.A.S.C.

II. REPORTS OF TREASURERS OF CENTRES

TORONTO CENTRE

Receipts		Disbursements	
Balance from previous year	$ 66.31	Rentals	$ 44.00
(190) Members' Fees	326.00	Fees to General Treasurer	326.00
Grant from General Council	149.50	Postage and Stationery	35.33
Bank Interest	nil	Expenses re meeting	15.00
Grant from Exhibition: re Telescope in grounds	75.00	Expenses: Re Telescope at Exhibition: Cartage $4.00, Insurance 5.00	9.00
			$429.33
		Balance carried forward	187.48
Totals	$616.81		$616.81

December 2nd, 1941.

(Signed) T. H. MASON, *Treasurer.*

OTTAWA CENTRE

Receipts		Disbursements	
Balance from previous year	$124.68	Fees to General Treasurer	$102.00
40 Members' Fees	88.00	Postage and Stationery	2.83
Grant from General Council	51.00	Expenses: Flowers, etc.	4.00
Bank interest	.44	Balance carried forward	155.29
Totals	$264.12		$264.12

Audited and found correct, December 2, 1941.

(Signed) D. B. NUGENT, *Auditor.*

HAMILTON CENTRE

Receipts		Disbursements	
Balance from previous year	$ 18.98	Rentals	$ 20.00
(57) Members' fees	$114.00	Fees to Gen. Treasurer	$ 96.00
Grant from General Council	44.00	Postage and Stationery	11.62
Bank interest	.30	Expenses re meeting	12.50
Field Night	10.07	Printing	9.00
Donation	1.00	Exchange on cheque	.15
		Gift to Fresh Air Fund	10.00
		Balance carried forward	29.08
Totals	$188.35		$188.35

Audited and found correct.

(Signed) WM. FINDLAY

JAMES R. GRAHAM, *Sec.-Treas.*

WINNIPEG CENTRE

Receipts		Disbursements	
Balance from previous year	$ 30.25	Rentals	$ 13.50
(32) Members' Fees	64.00	Fees to General Treasurer	65.00
Grant from General Council	29.00	Postage and Stationery	7.50
Bank interest	.36	Expenses re meeting	5.85
Exchange	.21	Balance carried forward	31.97
Totals	$123.82		$123.82

December 10, 1942.

ROBERT S. EVANS, *Treasurer.*

VANCOUVER CENTRE

Receipts		Disbursements	
Members' Fees	$ 65.00	Balance (deficiency) from 1940.	$ 1.13
Grant from General Council	30.00	Rentals	Nil
Bank interest	.37	Fees to General Treasurer	65.00
		Postage and Stationery	4.05
		Programmes	7.56
		Expenses re meetings	8.50
		Bank charges	.35
		Balance carried forward	8.78
Totals	$ 95.37		$ 95.37

LAURA ANDERSON, *Treasurer.*

MONTREAL CENTRE

Receipts		Disbursements	
Balance from previous year	$277.33	Rentals	Nil
(96) Members' Fees	192.00	Fees to General Treasurer	$192.00
Grant from General Council	92.00	Postage and Stationery	82.75
Bank interest	3.80	Expenses re meeting	
		Balance carried forward	290.38
Totals	$565.13		$565.13

HENRY F. HALL, *Sec.-Treas.*

VICTORIA CENTRE

Receipts			Disbursements		
Balance from 1940		$115.66	Rentals		$ 42.79
Fees (11 Juniors)		173.50	To General Treasurer		173.50
From General Council		88.25	Postage and Stationery		21.20
Bank interest		.46	Books, Magazines, etc.		31.00
Miscellaneous:			Miscellaneous:		
Annual Dinner	$2.55		Flowers	$4.00	
Donation	.50		Cartage	2.00	
		3.05	R. Hopkin	4.00	
					10.00
			Trust Fund—1941 Victory Bond		50.00
			Balance carried forward		52.43
Totals		$380.92			$380.92

Audited and found correct.
(Signed) J. A. PEARCE

PHOEBE RIDDLE, *Secretary-Treasurer.*

LONDON CENTRE

Receipts		Disbursements	
Balance from previous year	$ 17.35	Rentals	$ 2.00
(43) Members' Fees	86.00	Fees to General Treasurer	78.23
Grant from General Council	37.00	Postage and Stationery	11.64
Bank interest	.39	Expenses re meeting	11.57
			$103.44
		Balance carried forward	37.30.
Totals	$140.74		$140.74

Audited and found correct.

JOHN MIDDLEBROOK
E. H. McKONE

EDMONTON CENTRE

Receipts		Disbursements	
Balance from previous year	$119.25	Rentals	Nil
(44) Members' Fees (1940-1941)	98.00	Fees to General Treasurer	$ 74.00
Grant from General Council	37.00	Postage and Stationery	5.00
Bank interest	2.18	Expenses re meeting:	
Handbooks for students	2.50	For Janitor's Services	10.50
		" Refreshments	3.60
		Library Books and Cupboard	33.90
		The Sky Magazine (2 years)	4.88
		Memorial Flowers	3.00
		Bank charges on three cheques	.65
		Balance carried forward	123.40
Totals	$258.93		$258.93

Note:

38 members paid $2.00 each	$ 76.00
6 " " $4.00 "	24.00
44 members paid Total	$100.00

Audited and found correct.

H. R. LEAVER, *Auditor.* E. N. HIGINBOTHAM, *Treasurer.*

OFFICERS FOR 1942

The Secretaries of the various Centres report the following officers elected for 1942:

TORONTO CENTRE

Honorary Chairman—C. A. CHANT, M.A., PH.D., LL.D.
Chairman—D. W. BEST, D.D.
Vice-Chairman—MISS RUTH NORTHCOTT, M.A.
Secretary—TRACY D. WARING, 44 Rosepark Dr.
Treasurer—T. H. MASON. *Recorder*—F. L. TROYER. *Curator*—R. S. DUNCAN.
Council—D. S. AINSLIE, PH.D.; L. GILCHRIST, PH.D.; J. F. HEARD, PH.D.; F. S. HOGG, PH.D.; J. H. HORNING, M.A.; P. M. MILLMAN, PH.D.; REV. C. H. SHORTT, M.A.; R. K. YOUNG, PH.D.; W. T. PATTERSON, R.O.; MISS E. M. FULLER, B.L.S.; H. DUNCALFE; and *Past Chairmen*—J. R. COLLINS, E. J. A. KENNEDY, and S. C. BROWN.

OTTAWA CENTRE

Honorary President—MISS MIRIAM S. BURLAND. *President*—F. W. MATLEY.
First Vice-President—T. L. TANTON, PH.D.
Second Vice-President—HOYES LLOYD.
Secretary—MALCOLM M. THOMSON, Dominion Observatory.
Treasurer—ANDREW C. STEEDMAN.
Council—MRS. A. A. LOWES; H. M. BRADLEY; C. B. REILLEY, K.C.; W. W. NICHOL, B.A.; R. J. MCDIARMID, PH.D.; and *Past Presidents*—JOHN MCLEISH, B.A.; A. H. MILLER, M.A.; R. G. MADILL, B.A.

HAMILTON CENTRE

Honorary President—W. T. GODDARD. *President*—H. B. FOX.
Secretary-Treasurer—J. R. GRAHAM, 64 Blake St.
Curator—T. H. WINGHAM, B.A.SC.
Council—F. H. BUTCHER, B.A.; T. M. NORTON; WM. FINDLAY, PH.D.; A. E. JOHNS, M.A., PH.D.; G. E. CAMPBELL, M.A.; W. S. MALLORY, M.A.; REV. E. F. MAUNSELL; N. H. BROADHEAD (deceased); MISS NELLIE CORKE; MISS GRACE MASON.

WINNIPEG CENTRE

Honorary President—Monsignor T. W. MORTON. *President*—L. W. KOSER.
First Vice-President—V. C. JONES.
Second Vice-President—MISS O. A. ARMSTRONG.
Treasurer—R. S. EVANS. *Secretary*—MISS M. E. WATTERSON.
Council—R. D. COLQUETTE; L. J. CROCKER; C. A. E. HENSLEY; W. P. JOHNSON; G. P. MORSE; H. E. RITER; A. W. SMITH; A. V. THOMAS; PROF. L. A. H. WARREN; P. C. WATT.

MONTREAL CENTRE

Honorary President—MGR. C. P. CHOQUETTE.
President—D. P. GILLMOR, K.C. *Vice-President*—G. H. HALL.
Secretary—H. F. HALL, Sir George Williams College, 1441 Drummond Street, Montreal, Que.
Treasurer—F. J. DEKINDER.
Council—O. A. FERRIER; DELISLE GARNEAU; A. M. DONNELLY; G. R. LIGHTHALL; E. P. MORGAN; E. RUSSELL PATERSON; DR. W. B. ROSS; DR. A. M. SHAW.

VICTORIA CENTRE

Honorary President—GORDON SHAW. *President*—R. M. PETRIE, PH.D.
First Vice-President—CAPTAIN WM. EVERALL.
Second Vice-President—O. M. PRENTICE.
Secretary-Treasurer—MISS M. OLIPHANT.
Recorder—ROBERT PETERS. *Librarian*—MISS C. HAILSTONE.
Director of Telescope Making Section—W. HOBDAY.
Council—MISS Y. LANGWORTHY; A. MCKELLAR, PH.D.; MRS. J. R. NOBLE; W. STILWELL, M.A.; MARK TRUEMAN; K. O. WRIGHT, PH.D.

LONDON CENTRE

Honorary President—DR. H. R. KINGSTON.
Past President—REV. W. G. COLGROVE, M.A., B.D.
President—T. C. BENSON. *Vice-President*—DR. G. R. MAGEE.
Secretary-Treasurer—DR. RANDAL H. COLE, University of Western Ontario.
Council—REV. M. E. CONRON; MRS. G. E. Wood; J. W. BRYCE; E. H. MCKONE; D. M. HENNIGAR.

VANCOUVER CENTRE

Honorary President—DR. J. A. PEARCE, Dominion Astrophysical Observatory.
President—CAPTAIN C. A. MCDONALD. *Vice-President*—A. OUTRAM.
Recording Secretary—R. E. G. LANGTON, M.A.
Corresponding Secretary—H. D. SMITH, PH.D.
Treasurer—MRS. LAURA ANDERSON.
Council—C. JORGENSON; MRS. C. A. ROGERS; F. R. STEWART; C. E. BASTIN; DR. RALPH HULL; N. D. B. PHILLIPS; DR. G. M. VOLKOFF; M. A. MCGRATH.

EDMONTON CENTRE

Honorary President—J. W. CAMPBELL, PH.D.
President—MRS. G. A. CLARKE. *Vice-President*—J. A. MCLEAN.
Secretary—E. H. GOWAN.
Treasurer—E. N. HIGINBOTHAM.
Librarian—E. S. KEEPING.
Council—H. R. LEAVER; C. G. WATES; G. W. ROBERTSON; A. COTSMAN; J. J. TUCK.

MEMBERS AT LARGE ELECTED SINCE AUGUST, 1941

ANDREWS, REX B., R. 1, Box 422, Santa Cruz, Cal.
APGAR, CHAS. E., 549 Carleton Rd., Westfield, N.J.
BEARDALL, JOHN, Radio Station CFCO, Chatham, Ont.
BELLEFEUILLE, JEAN DE, 4530 de Lorimier St., Montreal, P.Q.
BIGGS, WM., 11 East 68th St., New York, N.Y.
BISSONNETTE, L. H., St. Michel de Bellechasse, P.Q.
BODDY, A. J. A., St. Catharines Flying School, St. Catharines, Ont.
BOGRAND, WILLIAM H., 328 Hughes Ave., Pontiac, Mich.
BOIVIN, ALBÉRIC, 914 Chemin Ste-Foy, Quebec, P.Q.
BOLLA, MRS. ELMER T., 1722 Carnation St., Harrisburg, Pa.
CAMERON, H. G., 1708 S. Curtis Ave., Alhambra, Cal.
DAVIS, JAMES H., 366th Infantry Co. F., St Devens, Mass.
DAY, MISS GERTRUDE, 671 Putnam Ave., Detroit, Mich.
GANT, J. QUINCY, M.D., National Institute of Health, Bethesda, Md.
HALLUM, L., Attorney-at-Law, Aitken, Minn.
HANNAM, W. H., 1116 Financial Center Bldg., San Francisco, Cal.
HAWLEY, A. H., 6233 Cambridge Ave., Cincinnati, Ohio.
HESS, ANTON, 10011 Anderson Ave., Cleveland, Ohio.
HEWITT, W. T., 1705 Summit Ave., Seattle, Wash.
HEXTALL, A. C., 16 Grandview Parade, Epping, New South Wales, Australia.
HOUSTON, C. L. R., 257 S. Kenmore Ave., Los Angeles, Cal.
HULL, W. A., 2355 Morris Ave., Bronx, New York, N.Y.
ISKER, B. J., D.Sc. 113 Central Ave., Buffalo, N.Y.
JESSEN, EARL, 423 Laurel St., San Francisco, Cal.
JONES, C. W., D.D.S., Anderson, Ind.
KENNY, E. R., Box A7, Englehart, Ont.
MACGREGOR, J. A., 40 Ploermel Ave., Quebec, P.Q.
MACLURE, K. C., R.C.A.F. Officers' Mess, Calgary, Alta.
MANTLER, J. R., 144—42 Northern Blvd., Flushing, N.Y.
MATISHECK, PETER H., 719 S. 9th St., Bozeman, Mont.
OSTROM, C., Alexandria, Ont.
PARNALL, H. W., Foothills, Alberta.
PETERS, R. H., 54 Broad St., Pascoag, Rhode Is.
POIRIER, ALPHEE, M.D., St. Damien, Bellechasse, P.Q.
RITTER, E. F., 104 North Fulton Ave., Baltimore, Md.
SACHS, J., 28 West 69th St., New York, N.Y.
ST. JOHN, RICHARD, 6811 9th St. N.W., Washington, D.C.
SCOTT, MRS. LAVERNA, 202 Franklin Ave., Vandergrift, Pa.
SKINNER, E. W., c/o Brigham Hall Hospital, Canandaigua, N.Y.
SOUTHER, B. L., 24 Harrison Ave., New Canaan, Conn.
URASE, M., P.O. Box 236, Steveston, B.C.
WADSWORTH, B., 103 Harvard Ave., Modesto, Cal.

NOTES AND QUERIES

Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.

Death of Norman H. Broadhead

A great loss to our Society occurred in the death of Norman H. Broadhead at his home, 15 Mapleside Ave., Hamilton, on January 28, 1942, at the age of 57. Mr. Broadhead was president of the Hamilton Centre during 1940 and 1941. At the recent elections to the General Council of the Society he was chosen a member, but passed away before he could take his place at a meeting. In business life he was a cost accountant and he was the author of a book on that subject which achieved wide success. He was also an active worker in the Hamilton Scientific Association, being its corresponding secretary at the time of his death.

Mr. Broadhead was a gifted musician and formerly belonged to the Hamilton Symphony Orchestra. In addition he was for some years a member of the Central Presbyterian Church and its choir. He was modest in his demeanour but took a kindly and active interest in all his associates. Any project he espoused he carried out with energy and enthusiasm. While presiding officer of the Centre he introduced some interesting novel features which added to the attractiveness of the meetings. His fellow members of the Society at Hamilton esteemed him very highly, and placed on his casket a beautiful wreath as a token of their friendship. Surviving are his wife; a daughter, Mrs. Donald Stewart of Toronto; and a son David in the R.C.A.F.

John S. Plaskett at the University of Toronto

In the article with the above title in the December 1941 number of this Journal the date when Mr. Plaskett entered the service of the University was left somewhat in doubt (p. 413). A search in the archives of the University and of the Provincial Secretary's department did not reveal the original minute of the authority appointing him, but in the statement of expenditures during the college year 1889-90 it was recorded that he had been paid salary for six months. From this it is to be concluded that he began on January 1, 1890.

Astronomical Affairs in Mexico

A new astrophysical observatory, having as its chief instrument a 27-31-inch Schmidt-type telescope, was dedicated at Tonanzintla on February 17 last; and in connection with this an Inter-American Astrophysical Conference was held. Among those on the programme was Director J. A. Pearce of the Dominion Astrophysical Observatory, Victoria, B.C., who will supply an account of the meetings for the Journl. On his way home Dr. Pearce gave an illustrated address on "The Rotation of the Galaxy" at the University of California at Los Angeles.

Distance of Globular Cluster 47 Tucanae

A new determination of the distance and absolute luminosity of the above cluster has recently been published by Dr. Harlow Shapley of the Harvard Observatory. It appears definite that the cluster has ten times the luminosity of the average globular cluster and is therefore of the same order of brightness, and probably of the same order of total mass, as various stellar systems that are now placed in the category of galaxies.

This cluster is a close companion in the sky of the Small Magellanic Cloud. Their centres are less than three degrees apart and the great cluster is actually within the projected bounds of the Cloud as defined by its outlying Cepheid variables and star clusters.

The procedure followed in the study of these objects has been developed by Dr. Shapley and may fairly be described as "technical." The distance in this case is determined from measures of its brighter stars and it comes out 7200 parsecs or 23,000 light-years, about ten per cent. greater than the previously accepted value. The absolute magnitude is given as -10.2.

A remarkable feature of this globular cluster is the presence in it of three variable stars with the great periods of 212.40, 202.84 and 192.34 days. They are all believed to be super-giants. Only four other variable stars with periods greater than 125 days are known in globular clusters. Full details of this investigation are given in *Proceedings* of the National Academy of Sciences, September 1941.

THE PAINTED DESERTS OF MARS

Although little oxygen and water now remain on Mars, they were probably abundant in the distant past. The red deserts tell the story of the lost oxygen, which may have combined with the iron of the rocks to produce the striking shades of red and ochre. The oxygen literally rusted away. Lack of mountains suggests that water erosion was also active in the past. The moon and the earth have very irregular surfaces, while Mars, intermediate in diameter and mass, presents a much smoother exterior. The small planet, after its formation, probably cooled more quickly than the earth and, like the moon, became rigid in an earlier stage of its development. . . . Streams and seas, in the remote past, may have rendered Mars as fertile and fruitful as the earth to-day.

As the aeons rolled by, the atmosphere thinned and the oxygen and water vapour were lost, mostly by chemical combination with the surface rocks. In addition, the low velocity of escape, only 3.1 miles per second, may have permitted an exceedingly slow but appreciable loss of the atmosphere, particularly of hydrogen and helium. The outermost cold layers of the planet absorbed rather than augmented the supply of gases and liquids on the surface. In such a fashion Mars may have aged, to become the dying world that we observe to-day.

The great maria and the other dark areas may well be the silt-filled beds of the ancient seas. . . . The lack of water has rendered the red deserts barren, like the deserts of the earth. The Painted Desert of Arizona, an ancient ocean bed stratified by sedimentary rocks, was once a verdant forest region, of which only the petrified forest remains to-day. The deserts of Mars may well be as beautiful as this incredible area of the earth. . . .

Whether intelligent beings exist to appreciate these splendours of the Martian landscape is pure speculation. . . . We do not know the origin of life, even on the earth. We are unable to observe any signs of intelligent life on Mars. The reader may form his own opinion. If he believes the life force is universal and that intelligent beings may have once developed on Mars, he has only to imagine that they persisted for countless generations in a rare atmosphere which is nearly devoid of oxygen and water, and on a planet where

the nights are much colder than our arctic winters. The existence of intelligent life on Mars is not impossible but it is completely unproven.—From *Earth, Moon and Planets*, by F. L. Whipple, reviewed in the January number.

Rotation of the Galaxy

Another solution of the grand problem presented by our galaxy considered as a dynamical system is outlined in *Monthly Notices*, vol. 101, no. 7, 1941. A paper by A. Ali gives the results obtained in an investigation made at the University Observatory, Glasgow. He utilized radial velocities of O- and B-type stars as listed in Moore's *General Catalogue*, together with a few recently published values; but in order to get a homogeneous set of stars with reliable radial velocities he excluded certain stars of various classes. In this way he obtained 788 stars which he believed should yield results of high weight. The circular velocity of the sun, as determined from its motion with respect to the globular clusters and the extra-galactic nebulae, is taken to be 275 km./sec.

The final results are:

Period of rotation in the neighbourhood of the sun, $1 \cdot 9 \times 10^8$ years.
Distance from the sun to the centre of rotation, 8,700 parsecs (28,000 light-years).
Longitude of centre, 321°.5.

The values given by Plaskett in the Halley Lecture for 1935, and summarized by him in this Journal, (vol. 30, p. 153, 1936) are:

Period of rotation at sun, 224,600,900 ($2 \cdot 2 \times 10^8$) years.
Distance from sun to centre, 10,000 parsecs.
Total mass of galaxy, $16 \cdot 5 \times 10^{10}$ suns.
Longitude of centre, 327°.

C. A. C.

MEETINGS OF THE SOCIETY

THE ROYAL ASTRONOMICAL SOCIETY OF CANADA
ANNUAL AT HOME

January 20, 1942.—The annual At Home of the Society was held this evening in the Physics Building of the University of Toronto. There was a large attendance of members and friends.

The chair was taken by Dr. F. S. Hogg, President, who delivered the address of the evening on the subject of "Navigation by the Stars." The thanks of the meeting were conveyed to Dr. Hogg by Professor A. E. Johns.

Following the President's address demonstrations illustrating the use of the Electron Microscope were given by Dr. L. T. Newman and Mr. J. H. L. Watson.

Mr. E. J. A. Kennedy, General Secretary, presented the report of the Chant Medal Committee, the medal for this year being awarded to Mr. H. Boyd Brydon, of Victoria.*

Dr. D. W. Best announced the subjects and names of the speakers for the spring meetings of the Toronto Centre.

The public meeting then adjourned, and an hour was spent in social intercourse with refreshments.

H. W. BARKER, *Recorder.*

AT OTTAWA—ANNUAL MEETING

December 3, 1941.—The 1941 annual meeting of the Royal Astronomical Society, Ottawa Centre, was held in the Lecture Hall of the National Museum at 5.15 p.m., with Mr. F. W. Matley presiding.

Miss Burland and Mr. Hatton were appointed scrutineers to count the ballots, 24 of which had been received by the time of the meeting.

Reports of the secretary and treasurer were read and approved on motion of Mr. Thomson and Dr. Tanton. A growing interest in astronmy is evident. The membership of the senior section has remained steady, and in addition a Junior Astronomical Club has been organized with regular fortnightly meetings at the Observatory. This is sponsored by the senior society, but is directly under the supervision of the secretary assisted by Miss Burland, and by Mr. B. L. Bradley and Mr. M. V. Morwick, teachers at the Technical High School. Interest is also shown by the large groups of people who visit the Observatory dome on clear Saturday nights.

On motion of Mr. Lloyd and Mr. Hatton, the secretary was instructed to express the thanks of the Centre to the officials of the Ottawa press, the Museum, and the Dominion Observatory for courtesies during the past year.

*An account of the presentation of the medal to Mr. Brydon appears on page 97.

The scrutineers presented the results of the voting. [The officers for 1942 appear on another page].

Mr. McLeish raised the question about the amount of benefit the "Sky Facts" had on membership in the Society, and also on the attendance on Saturday nights at the Observatory. There appeared to be little benefit to the membership of the Society, but certainly on clear Saturday evenings, the dome has been well attended. And of course this fall has seen the organization of a Junior Club. It was felt that Astronomy should merit a larger membership from the people of Ottawa, many of whom are technically trained. Mr. Matley pointed out again that apparently "Sky Facts" are appreciated because the Citizen Press seems eager to have us keep the column alive. Mr. Lloyd suggested that a question and answer section might be included in the column to encourage more interest, and added that we could even write an editorial comment concerning "Sky Facts." Also it would be advisable to include descriptions of objects to be seen on Saturday nights, said Dr. Tanton.

It was felt that in the report of this meeting to the press a word for the Society might be included. Special reference should be made to the HANDBOOK which is free to all members, and which includes a great deal of interesting information concerning popular astronomy.

M. M. THOMSON, *Secretary.*

AT TORONTO

November 4, 1941.—The Society met in the McLennan Laboratory, University of Toronto, at 8.00 p.m., Dr. D. W. Best in the chair.

Mr. Herbert A. Waddington, 31 Gould Street, Toronto, was duly elected to membership in the Society.

"Waves in Light and Sound" was the subject of an address by Dr. Florence Quinlan, Department of Physics, University of Toronto. She was introduced by Miss Ruth J. Northcott. She demonstrated many of the characteristics of wave motion by experiments, and defined such terms as wave-length, frequency, amplitude, pitch, resonance, interference and standing waves. Mr. S. C. Brown expressed the thanks of the audience to Dr. Quinlan.

A tribute to the late Dr. John Stanley Plaskett, past president of the Society and former director of the Dominion Astrophysical Observatory at Victoria, was paid in a memorial address by Dr. Helen Sawyer Hogg. "Canadian astronomy suffered a great loss with Dr. Plaskett's death. He was more than merely an astronomer. He was one of the most eminent scientists on this continent. He won many degrees, medals and honours, and merited every one," Dr. Hogg said.

He went to the Dominion Observatory at Ottawa from the staff of the physics department, University of Toronto. While there he foresaw the need for a large telescope operating under ideal seeing conditions, and it was largely due to his vision that the Dominion Astrophysical Observatory was established. Dr. Plaskett displayed a genius in many directions, Dr. Hogg said. "The 72-inch

telescope at Victoria, built to his own design, remains as a permanent monument to his work," she pointed out. In the astronomical world, Dr. Plaskett was probably best known for his determination of the galactic rotation based on thousands of measurements of stellar motions. Retired since 1935, he died at his home in Esquimalt, British Columbia, on October 17, 1941.

Dr. Hogg then gave the third paper in a series on "Explorations in Clusters and Nebulae," dealing with globular clusters. About 94 such objects are now known, and the number has not greatly increased during the last half-century despite the use of larger and larger telescopes. Seen as hazy patches under good seeing conditions, globular clusters exhibit a remarkable distribution with respect to the Milky Way, avoiding the central plane of the galaxy. One-third of the clusters known are found in the Sagittarius-Scorpio region in the heart of the galaxy. Clusters are found above and below, and on the edges of the Milky Way.

Determination of the distances of globular clusters is hampered by absorption of light in space. Allowing for recently determined corrections, their distances run from 10,000 light-years for Omega Centauri, up to about 180,000 light-years. Linear diameters are about 100 light-years, but some are as high as 300. Messier 13, in Hercules, a typical globular cluster, is about 25,000 light-years distant and about 100 light-years in diameter.

Each cluster contains up to several hundred thousand individual stars, few of which are brighter than absolute magnitude –1. These stars are arranged in a very symmetrical manner with a concentration toward the centre. More than 1200 variable stars are known in these clusters. Most of the variables are of the cluster type with periods less than one day, a few are very luminous long-period Cepheids. Radial velocity observations for 26 clusters are unusually high, the greatest being –365 km./sec.

The number of globular clusters in our galaxy is estimated to be more than 200, but the majority, especially the distant ones, are obscured by dark matter in space. The amount of starlight so obscured is now roughly known and the distribution of the obscuring matter is also becoming better known to astronomers, Dr. Hogg said.

FREDERIC L. TROYER, *Recorder.*

November 18, 1941.—The Society met in the McLennan Laboratory, University of Toronto, at 8.00 p.m., Dr. D. W. Best in the chair. Minutes of the previous meeting, held November 4, 1941, were taken as read.

A letter from the Canadian Broadcasting Corporation was referred to Council. It asked that arrangements be made to have short summaries of papers read before the Society prepared for broadcast.

Mr. R. Walton, 871 Millwood Road, Leaside, Toronto, was duly elected to membership in the Society.

Mr. W. T. Patterson, R.O., of Guelph, then addressed the Society on "Telescope Construction and Mirror Testing." He demonstrated specimens of some materials he had found useful in constructing tubes, mountings and mirror

cells. "The real amateur will never buy anything if he can make it," Mr. Patterson said. Metal track used for showcase doors was an exceptionally good material for making strong tubes, he pointed out. Speaking on mirrors, he said that extra time spent in the final stages of fine grinding would save many hours in the polishing process. He concluded his talk by demonstrating methods of testing mirror surfaces, and displayed several telescopes and parts of his own manufacture.

Dr. Helen Sawyer Hogg then gave the fourth in a series of talks on "Explorations in Clusters and Nebulae." Dealing with the dark diffuse nebulae she said, "Astronomers feel there is no place in the sky of any extent where there is actually nothing. If we see what appears to be a blank, it is because there is some dark cloud-like matter between us and the stars." Dr. Hogg quoted Prof. H. D. Curtis' definition of diffuse nebulae: "Rightly to be regarded as *par excellence* the actual nebulous elements of the cosmos; irregular cloud-like formations of tremendous extent, of random and inchoate structure, of the utmost tenuity, and composed of finely divided matter or matter in the atomic or molecular state." The "Horsehead Nebula" in Orion was a good example of this type, she said.

Some 1,500 of these "black spots" had been catalogued by Lundmark and Melotte, but the actual number of individual diffuse nebulae must be much less because they were undoubtedly connected in large groups. Usually close to the galactic plane, they were not often found in high galactic latitudes. Their general haze effect near the plane of the Milky Way tended to cut down the light of background stars about 1.5 magnitudes for each 5,000 light-years distance. "These clouds prevent us from seeing what must be the massive nucleus of our own galaxy in the direction of the constellation Sagittarius," Dr. Hogg said. Little of the haze which cut down the light of background stars was observed in regions free of the dark nebulous clouds.

Light was not so much absorbed by these nebulae as it was scattered, the scattering power of the matter comprising them being better than that of meteoric dust. Composition of the nebulae was unknown but their light scattering properties were similar to those of ice crystals, Dr. Hogg added. Stationary lines of calcium observed in the spectra of distant stars, but which did not originate in the stars themselves, gave some idea of the composition of these clouds of interstellar matter, the density of which was as small as 10^{-24} that of air. Calcium, potassium, titanium, sodium and carbon compounds have been observed in these clouds but 90 per cent. of this interstellar matter was probably free hydrogen, the spectral lines of which would be cut off by the earth's atmosphere, Dr. Hogg said.

The next meeting in Toronto being the "annual business meeting," it was moved by Mr. S. C. Brown, seconded by the Recorder, that a Nominating Committee be appointed. A resolution was then duly moved and seconded that the Nominating Committee consist of Mr. J. R. Collins as chairman, with Messrs. E. J. A. Kennedy, T. H. Mason, H. G. Duncalfe, and S. C. Brown. Carried.

FREDERIC L. TROYER, *Recorder.*

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1890-1941

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